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Incidence, Predictors, and Outcomes associated with Post-operative Atrial Fibrillation after Major Non-Cardiac Surgery

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Abstract

Background—Although major non-cardiac surgery is common, few large-scale studies have examined the incidence and consequences of post-operative atrial fibrillation (POAF) in this population. We sought to define the incidence of POAF and its impact on outcomes after major non-cardiac surgery.

Methods—Using administrative data, we retrospectively reviewed the hospital course of adults who underwent major non-cardiac surgery at 375 US hospitals over a 1-year period. Clinically significant POAF was defined as atrial fibrillation occurring during hospitalization that necessitated therapy.

Results—Of 370447 patients, 10957 (3.0%) developed clinically significant POAF while hospitalized. Of patients with POAF, 7355 (67%) appeared to have pre-existing atrial fibrillation and 3602 (33%) had newly diagnosed atrial fibrillation. Black patients had a lower risk of POAF (Adjusted Odds Ratio, 0.53; 95% CI, 0.48 to 0.59; P<0.001). Patients with POAF had higher mortality (Adjusted Odds Ratio, 1.72; 95% CI, 1.59 to 1.86; P<0.001), markedly longer length of stay (Adjusted Relative Difference, +24.0%; 95% Confidence Interval [CI], +21.5% to +26.5%; P<0.001), and higher costs (Adjusted Difference, +$4177; 95% CI, +$3764 to + $4590; P<0.001). These findings did not differ by whether POAF was a recurrence of pre-existing atrial fibrillation, or a new diagnosis.

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Conclusion—POAF following non-cardiac surgery is not uncommon and is associated with increased mortality and cost. Our study identifies risk factors for POAF, which appear to include race. Strategies are needed to not only prevent new POAF, but also improve management of patients with pre-existing atrial fibrillation.

Keywords

atrial fibrillation; non-cardiac surgery; outcomes; complications

INTRODUCTION

Atrial fibrillation affects approximately 2.5 million people in the United States and roughly 10% of people over 80 years of age.[1] This dysrhythmia has been shown to be associated with increased mortality, even in young relatively healthy people.[2] Patients that develop atrial fibrillation in the peri-operative setting represent a poorly characterized subset of this population. An estimated 40–50 million non-cardiac surgeries are performed in this country each year and the number of procedures, as well as the average age of the patients, is steadily rising. As a result, the incidence of post-operative atrial fibrillation (POAF) can be expected to increase over time.

Recent evidence suggests that POAF complicating cardiac surgery increases health care costs and precipitates subsequent neurocognitive decline. As a result, strategies have been actively sought for the prevention of POAF after cardiac surgery. Subsequent research has shown that peri-operative administration of amiodarone, beta-blockers, and statins effectively decrease POAF in this population.[7–10]

The risks, mechanisms, and sequelae of atrial fibrillation after cardiac surgery are, at least in part, linked to the underlying cardiac disease and direct manipulation of the pericardium and myocardium during surgery, and therefore should not be fully generalized to patients undergoing non-cardiac surgery. Relatively little is known about the POAF as a complication of non-cardiac surgery. Pre-existing atrial fibrillation has been shown to be independently associated with increased mortality in patients undergoing non-cardiac surgery.[11] New-onset POAF following non-cardiac surgery has been studied only in small single-center studies. Given the large number of people who undergo these types of procedures, defining the scope of POAF in this population is important. We therefore assessed the incidence of POAF and its impact on outcomes after major non-cardiac surgery in a large nationwide cohort.

METHODS

Design Overview

We performed a retrospective cohort study using data from Premier Perspective, a database developed for quality and utilization benchmarking by Premier Incorporated, Charlotte, NC. The methods and design are the same as in our recently published data from this registry.[14] In addition to data elements available in the standard hospital discharge file, the Perspective

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database contains a date-stamped log at the individual patient level of all billed items, including medications as well as laboratory, diagnostic, and therapeutic services.

Setting and Participants

Patients were included in the analysis if they were 18 years of age or older and underwent major non-cardiac surgery between January 1, 2008 and December 31, 2008 at any of the 375 hospitals participating in Premier Perspective. Surgical procedures were categorized based on Diagnosis Related Groups (using APR-DRG software, version 27.0, 3M Corp, Minneapolis, MN) and were considered major if the mean length of stay for patients in the diagnosis related group was 3 days or more.[15] Procedures classified as cardiac and obstetric were excluded. The included list of procedures was then organized into nine categories of surgical type.

In order to discern new atrial fibrillation from chronic atrial fibrillation, cohort selection was focused on patients whose data had accurate and complete present-on-admission coding. These codes represent a date stamp in administrative data for secondary diagnoses and help determine which diagnoses are present at the time of admission. [16–18] Present-on-admission codes have been validated for in-hospital diagnoses of atrial fibrillation.[19] For any given hospital, we included patients who underwent surgery beginning the month that 100% of the cases of atrial fibrillation in that hospital had complete present-on-admission coding. Three hundred and seventy-five hospitals submitted data to Premier during the study time period. Of this 375, 46 hospitals were excluded because they had incomplete present-on-admission coding for all 12 months of the study period.

For each case, patient demographic information and hospital characteristics were recorded. Co-morbidities were established using a combination of *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* secondary diagnoses using standard methods.[20]

Permission to perform the study was obtained by the institutional review board at UCSF, San Francisco, CA and the requirement for informed consent was waived due to minimal risk to patients.

Outcomes and Follow-up

Definition of Post-Operative Atrial Fibrillation (POAF)—The designation of significant post-operative atrial fibrillation (POAF) was made using a secondary diagnosis *ICD-9-CM* code for atrial fibrillation (427.31) in combination with charge or procedure code data that suggested that the patient's dysrhythmia necessitated therapy. A combination of an *ICD-9-CM* code of 427.31 and one of the following was required for a diagnosis of POAF: an *ICD-9-CM* procedure code for electrical cardioversion in the post-operative period; pharmacy charge data for a new prescription of digoxin in the post-operative period; or pharmacy charge data for intravenous beta-blockers, intravenous calcium channel blockers, or intravenous amiodarone in the post-operative period.

Definition of peri-operative use of medications—We used pharmacy records to identify whether certain classes of medications were administered during the peri-operative

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period. We limited our "peri-operative" time window to day 0 (the day of surgery) and day 1.

Definition of agents likely to affect POAF risk—Peri-operative administration of digoxin, beta-blockers, angiotensin-converting enzyme inhibitors (ACE-Inhibitor), angiotensin receptor blockers (ARB), calcium channel blockers, anti-platelet, agents, or anti-arrhythmic drugs were assessed using pharmacy records. A similar approach was used to assess post-operative use of inotropes, vasopressors, warfarin, digoxin, intravenous beta-blockers, intravenous calcium channel blockers, or anti-arrhythmic drugs.

Administrative Outcomes—In-hospital mortality, length of stay, actual hospitalization costs, and 15-day and 30-day readmission rates were obtained from the Perspective discharge file.

Statistical Analysis

Summary statistics for the overall sample were constructed by using frequencies and proportions for categorical data and mean, median, and inter-quartile ranges for continuous variables. We also stratified these summary statistics by whether patients developed POAF.

Univariate logistic regression was used to determine the unadjusted association between patient, hospital, and surgery characteristics and POAF. We then constructed a multivariate logistic regression model to examine the association (adjusted odds ratio) between the covariates and POAF. A generalized estimation equations model with logit link, independence working correlation, and robust standard errors was employed. Two methods were used to determine which covariates to include in the model. First, a group of likely confounders (age, for example) was specified *a priori* and automatically included in the model for face validity. Second, another list of possible confounders was generated from clinical knowledge and data from prior studies. Confounders from this second group were kept in the model if they were found to change the model in a statistically significant manner ($p < 0.05$). Interaction terms chosen for clinical or biological plausibility were added to the base model and tested for statistical significance ($p < 0.05$). Co-variates were only allowed into the model if they were known at the time of surgery (i.e. post-operative medications or complications were not candidate co-variates). Variables included in the final model included: age, gender, race, hospital size (number of beds), surgery type, admission source, peri-operative administration of certain medications (statins, anti-arrhythmic drugs, beta-blockers, ACE-Inhibitors, ARBs, digoxin), and selected co-morbidities (hypertension, diabetes, congestive heart failure, ischemic heart disease, renal insufficiency, cerebrovascular disease, alcohol abuse, obesity, and pulmonary vascular disease).

Using the same methodology, models assessing POAF as the predictor of interest were constructed with multivariate logistic regression for dichotomous outcomes (mortality and readmission) and linear regression for continuous outcomes (cost and length of stay). In order to limit skew and maintain compliance with model assumptions, the cost variable was truncated (by dropping the upper 5% of the tail) and the length of stay variable was log transformed. Robust standard errors were used to account for clustering by hospital, arising from unmeasured differences in practice and expertise.

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All analyses were performed using STATA version 10 (Stata Corporation, College Station, Texas). No extramural funding was used to support this work. The authors are solely responsible for the design and conduct of this study, all study analyses, the drafting and editing of the paper and its final contents.

RESULTS

Patient characteristics (Tables I, II, III)

A total of 370447 patients meeting eligibility criteria underwent major non-cardiac surgery during the study period. Of these, 10957 patients (3.0%) developed POAF and 3602 patients (33% of all POAF patients) had atrial fibrillation classified as new by present-on-admission coding. Patients developing POAF were older; more often male; and much more likely to have congestive heart failure, ischemic heart disease, and hypertension.

Associations of patient race, co-morbidities, medications, and surgery type with incidence of POAF (Table IV)

After adjustment for patient risk factors, surgery type, and hospital factors in multivariable clustered logistic models, black race was associated with a markedly lower adjusted odds of developing POAF. Congestive heart failure, ischemic heart disease, and hypertension were associated with higher adjusted odds of developing POAF. Among key medications administered in the peri-operative period, statins, ACE-Inhibitors, and ARBs were all found to be associated with a significantly lower adjusted odds of developing POAF.

In a multivariable logistic model, we examined the association of surgery type with the incidence of POAF. The largest sub-group, orthopedic procedures, was used as the reference; the crude incidence of POAF for patients undergoing orthopedic surgery was 1.7%. Abdominal surgery was associated with the highest adjusted odds for developing POAF (Adjusted Odds Ratio [AOR], 1.82; 95% Confidence Interval [CI], 1.72–1.93).

Association between POAF and outcomes (Tables V,VI)

Outcomes were compared between patients who did and did not develop POAF. In a multivariate logistic regression model, patients developing POAF had a higher odds of mortality (AOR, 1.72; 95% CI, 1.59–1.86), longer hospital stays (Adjusted Relative Difference, +24.0%; 95% CI, 21.5%–26.5%), and increased hospitalization costs (Adjusted Difference, +$4177; 95% CI, $3764–$4590). There was no significant difference between the groups in the 30-day rate of readmission.

Analyses examining the association of new POAF with outcomes excluded all patients with pre-existing atrial fibrillation. New POAF (as determined by present-on-admission codes) had a similar association to mortality (AOR, 1.68; 95% CI, 1.52–1.86) as all POAF. New POAF was associated with extended hospital stays (Adjusted Relative Difference, +37.3%; 95% CI 33.9%–40.9%) and higher cost (Adjusted Difference, +$5914; 95% CI $5416–$6412).

A sensitivity analysis was performed by altering the outcome variable such that POAF was based solely on an ICD-9 code (427.31) with no clinical qualifiers. The association of POAF

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with mortality was attenuated but remained highly statistically significant (AOR, 1.24; 95% CI, 1.17–1.32; P<0.001).

COMMENT

In this large cohort of surgical patients, POAF occurred in about 3.0% of patients after non-cardiac surgery. Advancing age and congestive heart failure were associated with higher risk for POAF, while black race and peri-operative administration of statins, ARBs, and ACE-Inhibitors were associated with lower risk. Patients developing POAF had significantly higher mortality along with longer and more costly hospital stays.

Our results are consistent with prior findings that black patients have a lower adjusted risk than other patients of developing atrial fibrillation generally and after cardiac surgery specifically. [23–25] This study identifies race as an important part of the risk profile for POAF in the setting of major non-cardiac surgery.

Given the large number of patients who undergo major non-cardiac surgery, even relatively infrequent peri-operative complications can lead to a substantially increased burden of morbidity and cost. As such, peri-operative management strategies that can decrease the incidence of POAF in this population have the potential to be quite impactful; in our adjusted analyses, POAF was associated with $44 million in excess costs, in addition to the attendant increase in bed-days and higher mortality. It is, however, important to note that the position of POAF in the causal chain that leads to these worsened outcomes has yet to be established.

Of note, patients with pre-existing atrial fibrillation who developed POAF had similar outcomes compared with patients who appeared to develop POAF for the first time. These findings suggest that both primary and secondary prevention strategies are worth pursuing. Whether or not they have pre-existing atrial fibrillation, special attention is warranted for patients of advanced age, those with congestive heart failure, and those undergoing high-risk procedures (i.e. thoracic or abdominal surgeries). In such patients, more active pre-operative management of volume status in CHF patients and ensuring adequate ventricular rate control in patients with chronic atrial fibrillation may be appropriately included in the pre-operative plan. While no data exist to suggest that starting these agents in the peri-operative period is beneficial, our data suggest that continuation of statins, ACE-Inhibitors and ARBs may be beneficial in suppressing arrhythmias after non-cardiac surgery.

Our study has a number of limitations. The use of the ICD-9 code 427.31 alone (rather than in combination with the code for atrial flutter: 427.32) may decrease the sensitivity of the outcome variable. However, we chose a diagnosis code of 427.31 alone to gain maximum specificity with regard to our endpoint, with the understanding that some cases of atrial fibrillation would be missed due to miscoding or misinterpretation of the ECG. Other studies of atrial fibrillation which utilized administrative data have used a similar definition of atrial fibrillation.

Although POAF was strongly associated with poor outcomes in our cohort, it is possible that POAF simply mediates the association between other postoperative illnesses (such as sepsis)

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and outcomes. Because we used administrative data, we may have been unable to fully control for all such confounders. In addition, our data lacked detailed information about patients' past medical history, which prevented us from clearly discerning chronic medications from those initiated in the hospital. This also limited our ability to assess pre-operative functional status. The impact of atrial fibrillation on outcomes was attenuated by adjustment in the multi-variate regression model; given that the administrative data used for our analysis lacked clinical detail, it is possible that the inclusion of such data (were it available) would further diminish the association atrial fibrillation with poor outcomes and increased costs. We employed present-on-admission coding to discern incident from prevalent atrial fibrillation and used standard risk adjustment methodologies to account for patient risk factors. Though the use of these present-on-admission codes is becoming more common, many of the pitfalls involved with their use are related to potentially variable coding practices between hospitals. As a result of coding error, some of the cases of "new" atrial fibrillation may, in fact, have been "old" atrial fibrillation. However, these codes have recently been validated for atrial fibrillation.[19] Overall, we feel that it is unlikely that the problems associated with the use of administrative data would disproportionately affect any particular patient group.

In conclusion, results from this large observational study show the incidence of POAF following major non-cardiac surgery to be about 3.0%, with considerable variation by race and surgical category. This dysrhythmia is associated with markedly increased cost and mortality, regardless of whether or not patients had pre-existing atrial fibrillation. Our data identify subsets of the study population that are at particularly high risk for POAF. Interventions aimed at preventing POAF should be prospectively tested in these higher-risk groups.

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Table I

Clinical Characteristics of Patients Undergoing Major Non-Cardiac Surgery, Stratified by the Development of POAF

Characteristics	POAF N = 10957 (3.0%)	No POAF N = 359490 (97.0%)	P value
Age (years), mean (SD)	74.6 (10.6)	62.4 (16.2)	<0.001
Male gender	5435 (49.6%)	153831 (42.8%)	<0.001
Race/ethnicity			<0.001
White	8337 (76.1%)	252376 (70.2%)	
Black	628 (5.7%)	39004 (10.9%)	
Hispanic	226 (2.1%)	12905 (3.6%)	
Other	1766 (16.1%)	55205 (15.4%)	
Admission Source			<0.001
Emergency Room	4940 (45.1%)	112728 (31.4%)	
Inter-facility transfer	871 (7.9%)	15096 (4.2%)	
Outpatient referral	4923 (44.9%)	223831 (62.3%)	
Other	223 (2.0%)	7835 (2.2%)	
Co-morbidities			
Congestive Heart Failure	3340 (30.5%)	25319 (7.0%)	<0.001
Valvular disease	1720 (15.7%)	16345 (4.6%)	<0.001
Ischemic heart disease	4051 (37.0%)	63210 (17.6%)	<0.001
Peripheral vascular disease	1405 (12.8%)	23830 (6.6%)	<0.001
Hypertension	7706 (70.3%)	204597 (56.9%)	<0.001
Cerebro-vascular disease	480 (4.4%)	5547 (1.5%)	<0.001
Chronic pulmonary disease	3223 (29.4%)	61986 (17.2%)	<0.001
Diabetes	3269 (29.8%)	80236 (22.3%)	<0.001
Dyslipidemia	3741 (34.1%)	101698 (28.3%)	<0.001
Hypothyroidism	1789 (16.3%)	43473 (12.1%)	<0.001
Renal failure	2094 (19.1%)	35846 (10.0%)	<0.001
Coagulopathy	1333 (12.2%)	13769 (3.8%)	<0.001
Obesity	1193 (10.9%)	44558 (12.4%)	<0.001
Fluid & electrolyte disorders	5037 (46.0%)	70594 (19.6%)	<0.001
Anemia	3995 (36.5%)	81961 (22.8%)	<0.001
Alcohol abuse	366 (3.3%)	10261 (2.9%)	0.003

Abbreviations: POAF, Post-operative atrial fibrillation

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Table II

Surgery Type and Medications Administered during Hospitalization, Stratified by the Development of POAF

Characteristics	POAF N = 10957 (3.0%)	No POAF N = 359490 (97.0%)	P value
Type of surgery			<0.001
Intracranial	326 (3.0%)	8327 (2.3%)	
Spinal/Peripheral Nerve	397 (3.6%)	31113 (8.7%)	
Abdominal	3895 (35.6%)	86715 (24.1%)	
Genital-urinary	486 (4.4%)	26678 (7.4%)	
Orthopedic	2425 (22.1%)	136725 (38.0%)	
Otolaryngologic	347 (3.2%)	5279 (1.5%)	
Thoracic (Non-cardiac)	465 (4.2%)	7582 (2.1%)	
Vascular	570 (5.2%)	20590 (5.7%)	
Miscellaneous	2046 (18.7%)	36481 (10.2%)	
Peri-Operative Medications			
Statins	2114 (19.3%)	77757 (21.6%)	<0.001
Beta-blockers	3585 (32.7%)	100575 (28.0%)	<0.001
ACE inhibitors	2143 (19.6%)	71323 (19.8%)	0.466
Angiotensin receptor blockers	817 (7.5%)	35416 (9.9%)	<0.001
Anti-arrhythmics	583 (5.3%)	4082 (1.1%)	<0.001
Aspirin	1840 (16.8%)	48075 (13.4%)	<0.001
Calcium channel blockers	1140 (10.4%)	41965 (11.7%)	<0.001
Clopidogrel	454 (4.1%)	13114 (3.7%)	0.007
Prophylactic antibiotics	9981 (91.1%)	327752 (91.2%)	0.774
Pharmacologic VTE prophylaxis	7103 (64.8%)	158443 (44.1%)	<0.001
Mechanical VTE prophylaxis	2232 (20.4%)	33188 (9.2%)	<0.001
Post-operative therapy received			
IV Amiodarone	3083 (28.1%)	1566 (0.4%)	<0.001
IV beta-blocker	3970 (36.5%)	14547 (4.1%)	<0.001
IV calcium channel blocker	2555 (23.3%)	1335 (0.4%)	<0.001
Digoxin	5600 (51.1%)	3192 (0.9%)	<0.001
DC Cardioversion	810 (7.4%)	1317 (0.4%)	<0.001

Abbreviations: POAF, Post-operative atrial fibrillation; ACE, Angiotensin converting enzyme; VTE, venous thrombo-embolism; IV, intravenous

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Table III

Administrative Characteristics of Patients Undergoing Major Non-cardiac Surgery and Selected Outcomes

Characteristics	POAF N = 10957 (3.0%)	No POAF N = 359490 (97.0%)	P value
Primary payer			<0.001
Uninsured	17 (0.2%)	2477 (0.7%)	
Indemnity	387 (3.5%)	25129 (7.0%)	
Managed care	1089 (9.9%)	97131 (27.0%)	
Medicare/Medicaid	9128 (83.3%)	206020 (57.3%)	
Other	336 (3.1%)	28733 (8.0%)	
Characteristics of Hospitals			
Location			0.76
Rural	1133 (10.3%)	37491 (10.4%)	
Urban	9824 (89.7%)	321999 (89.6%)	
Area			<0.001
Midwest	1845 (16.8%)	68513 (19.1%)	
Northeast	3139 (28.7%)	97051 (27.0%)	
South	3702 (33.8%)	122238 (34.0%)	
West	2271 (20.7%)	71688 (19.9%)	
Number of beds			<0.001
0–99	274 (2.5%)	10888 (3.0%)	
100–199	980 (8.9%)	34332 (9.6%)	
200–299	1476 (13.5%)	50352 (14.0%)	
300–499	4133 (37.7%)	133877 (37.2%)	
> 500	4094 (37.4%)	130041 (36.2%)	
Teaching Hospital	2776 (25.3%)	92407 (25.7%)	0.38
Disposition			<0.001
Home	2176 (19.9%)	165734 (46.1%)	
Skilled Nursing Facility	3693 (33.7%)	71520 (19.9%)	
Home health care	1988 (18.1%)	80201 (22.3%)	
Died in Hospital	1549 (14.1%)	7402 (2.1%)	
Rehabilitation	960 (8.8%)	25949 (7.2%)	
Other	591 (5.4%)	8684 (2.4%)	
Outcomes			
Mortality	1549 (14.1%)	7402 (2.1%)	<0.001
Readmission 15-days	1066 (9.7%)	23626 (6.6%)	<0.001
Readmission 30-days	1584 (14.5%)	35421 (9.9%)	<0.001
Length of Stay Mean (SD)	15.0 (14.0)	6.9 (8.3)	<0.001
Hospitalization Cost Mean (SD)	42930 (49327)	21215 (24288)	<0.001

Abbreviations: POAF, Post-operative atrial fibrillation

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Table IV

Predictors of POAF – Race, Co-morbidities, Medications, and Surgery Type

Overall (N=370447)	Unadjusted POAF Rate (n=10957, 3.0%)	Adjusted OR [95% CI]	P value
Black race (39632)	628 (1.6%)	0.53 [0.49–0.58]	<0.001
Co-morbidities			
CHF (28659)	3340 (11.7%)	2.14 [2.01–2.27]	<0.001
DM (83515)	3269 (3.9%)	1.01 [0.96–1.06]	0.700
IHD (67261)	4051 (6.0%)	1.22 [1.16–1.27]	<0.001
HTN (212303)	7706 (3.6%)	1.16 [1.11–1.22]	<0.001
Medications			
Beta-blocker (104160)	3585 (3.4%)	1.01 [0.95–1.07]	0.678
Statin (79871)	2114 (2.6%)	0.79 [0.72–0.86]	<0.001
ACE-I (73466)	2143 (2.9%)	0.85 [0.81–0.90]	<0.001
ARB (36233)	817 (2.3%)	0.73 [0.66–0.81]	<0.001
Surgery Type			
Orthopedic (139150)	2425 (1.7%)	reference	reference
Otolaryngologic (5626)	347 (6.2%)	0.96 [.84–1.09]	0.528
Thoracic (8047)	465 (5.8%)	1.52 [1.36–1.70]	<0.001
Intra-cranial (8653)	326 (3.8%)	1.45 [1.28–1.64]	<0.001
Abdominal (90610)	3895 (4.3%)	1.82 [1.72–1.93]	<0.001
Genito-urinary (27164)	2046 (5.3%)	1.08 [0.97–1.19]	0.158
Vascular (21160)	570 (2.7%)	0.78 [0.71–0.87]	<0.001
Spine/Peripheral Nerve (31510)	397 (1.3%)	0.85 [0.76–0.94]	0.003
Miscellaneous (38527)	2046 (5.3%)	1.41 [1.31–1.51]	<0.001

Abbreviations: POAF, Post-operative atrial fibrillation; CHF, congestive heart failure; DM, diabetes mellitus; IHD, ischemic heart disease; HTN, hypertension; CRI, chronic renal insufficiency; ACE-I, angiotensin converting enzyme inhibitor; ARB, angiotensin receptor blocker

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Table V

Outcomes, Stratified by the Development of POAF

Outcomes	POAF (N=10957)	No POAF (N=359490)	Adjusted OR* [95% CI]	P value
Mortality	1549 (14.1%)	7402 (2.1%)	1.72 [1.59–1.86]	<0.001
Readmission at 30 days	1586 (14.4%)	35419 (9.8%)	1.00 [0.94–1.06]	0.999
			Adjusted Difference* [95% CI]	
Length of Stay, Median, [IQR]†	11 [6–19]	4 [3–8]	+24.0% [21.5%–26.5%]	<0.001
Hospitalization Cost, Median [IQR]‡	27164 [17133–49745]	15076 [10519–22769]	+4177 [3764–4590]	<0.001

Abbreviations: POAF, Post-operative atrial fibrillation

* Adjusted odds ratio or adjusted difference for the outcome, associated with POAF; regression models are fully adjusted

† Length of stay in days, log transformed in adjusted model

‡ top 5th percentile of cost removed to reduce skewness, cost is in dollars

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Table VI

Outcomes, Stratified by the Development of POAF among Patients without Pre-existing Atrial Fibrillation*

Outcomes	POAF (N=3602)	No POAF (N=339003)	Unadjusted OR [95% CI]	P value	Adjusted OR [95% CI]	P value
Mortality	570 (15.8%)	6646 (2.0%)	9.40 [8.57–10.31]	<0.001	1.68 [1.52–1.86]	<0.001
Readmission 30 days	529 (14.7%)	32338 (9.5%)	1.63 [1.49–1.79]	<0.001	1.02 [0.92–1.14]	0.673
			Unadjusted Difference in Means [95% CI]		**Adjusted Difference in Means [95% CI]**	
Length of Stay, median, [IQR]†	13 [8–22]	4 [3–7]	+275% [268%–182%]	<0.001	+ 37.3% [33.9%–40.9%]	<0.001
Hospitalization Cost, median, [IQR] ‡	25205 [18041–36280]	+14525 [10202–20987]	+10617 [10224–11011]	<0.001	+ 5914 [5416–6412]	<0.001

Abbreviations: POAF, Post-operative atrial fibrillation

* Patients with pre-existing atrial fibrillation, as determined by present-on-admission coding, were excluded from this analysis

† Length of stay log transformed in adjusted and unadjusted models, length of stay is in days

‡ top 5th percentile of cost removed to reduce skewness, cost is in dollars